Activity Guidelines for Impact Craters

Supplies:

- Several boxes filled with flour (flour is covered by a layer of tempura paint).
- Slide projector and several slides dealing with impact cratering
- Marbles (these are the impactors)
- Sling shot (for high velocity impacts)
- Additional dry tempura paint
- Rulers (for measuring the diameter and the length of ejecta for each crater).

The goal of this activity is to introduce students to impact cratering. Specifically we begin by discussing what impact craters look like, what they are, and how they form. It's best to start with a brief slide show that explains what impact craters look like on the Earth as well as on other planets. This may or may not include a discussion on the impact theory for the formation of the moon. Almost any slide that addresses impact cratering will be suitable, however, it is important to include at least one image of craters on the moon, specifically an image that show the production of ray-like ejecta (e.g. Copernicus crater). The remainder of this document will address what to do after the slide show (WARNING: It is best to do this activity outside!).

I. Impact cratering in a box

a. Bring at least one of the flour-filled boxes outside and set it down in a relatively open area. Try to make sure that the flour hasn't been sitting for too long otherwise not much ejecta will be produced. Therefore, it might be helpful to stir-up some of the flour and re-cover it with paint before you start the demonstration. If there are a large number of students it may be helpful to bring several boxes as well as assistants. Then one assistant at each box will lead the following discussion. If time permits, one student at each box should measure and record the diameter of the crater as well as the length of the ejecta.

b. Briefly discuss how to make the impact-crater box, so that the students can try this activity at home. Hot chocolate powder can be substituted for tempura paint.

c. Address the similarity between the box and the surface of a rocky-planet such as the earth. The flour represents the Earth's deep crust and possibly even the upper part of the mantle. The colored tempura paint represents the upper crust (the stuff we walk on). Based on that information, ask the students what is going to happen when an impactor hits the surface? Also ask why we care about the results of that impact (gives us a way to look at the lower levels of the Earth's surface without having to drill).

d. Now give a small marble to a relatively small student and have them drop the marble in the box. This will produce a crater with ray-like ejecta. Ask the students if this impact looks familiar. Hopefully at least one observant student will recognize that it looks like the Copernicus crater on the moon.

If time permits, have a student volunteer to measure and record the length of the ejecta and the diameter of the crater.

e. Ask the students how it would be possible to produce a larger crater (e.g. have a larger mass or produce higher velocity which can be increased first by dropping from a greater height and secondly by using a sling shot but don't reveal that information until later). Hopefully someone will suggest dropping the marble from a greater height. Then have a taller student drop a marble of similar size into the box and have a student measure the diameter of the crater and length of the ejecta. 90% of the time, this activity will produce a larger crater with longer ejecta. Note that especially with large craters, the diameter of the crater will be 10 times the size of the impactor that created it. Repeat this process as many times as necessary, while being sure to increase the height each time. The order of the next two steps can be changed based on preference.

f. Hopefully someone will have mentioned that one way to produce a bigger crater is to have a larger impactor. So using the process outlined in the previous step, have a student drop a large marble into the flour box and discuss the results.

g. Now ask the students how fast a large meteorite is traveling when it hits the ground. The answer is > 25,000 mph. Obviously this is very fast, in fact it's too fast for us to simulate in a lab, so what some scientists do is use a light-gas gun to shoot projectiles into slabs of aluminum. Well you obviously don't have that technology with you, but you do have a sling shot. Making sure that no students are in the line of fire, shoot one or two marbles into the box. Measure and discuss the results of this exercise. Then ask what will happen if the meteorite comes in at an angle. Once again, make sure that no students are in the way and shoot one or two marbles into the box at low angles. Measure and discuss the results. It might be helpful to discuss the similarity of these craters to those seen in movies such as *Armageddon* or *Deep Impact*.

h. Finally, ask the students if they know of any other way that it might be possible to model the effects of a meteorite slamming into the earth. Hopefully someone will mention the use of computers. It will then be possible to discuss the use of Super computers at national labs such as Sandia or Los Alamos. These computers essentially look at how each tiny particle behaves as it hits another particle, which then hits another particle, etc…

II. Follow up

Doing a full quantitative experiment as outlined in "Meteorite Mysteries" NASA publication, provides a lot more information and training for the students.

Impact Crater Simulation Instructions:

Start by dropping a marble from 20 cm, and do a drop for each additional 20 cm for as high as you care to go. For each marble drop you should measure different properties for each crater. Remember that 10 millimeters is one centimeter, and 100 centimeters is one meter. After doing the experiment you can calculate the depth/diameter ratio which is often measured for planetary craters. You can also calculate the kinetic energy from the formula K.E. = M x g x h, where M = mass in grams, g = the force of gravity on the earth (980 cm/sec^2), and h = height above surface in cm. A typical marble weighs 5.5 grams.

You can also graph the data. The most interesting charts are depth, diameter, diameter of ejecta, depth/diameter, versus the height or versus the kinetic energy. Remember to label all axes with the name and units.

You can now look at pictures of the Moon and planets and explain some of the features!

Data table for impact cratering (H. Newsom, 2002)

Height above surface, cm	Depth of crater, cm	Diameter of crater, cm	Radius of primary ejecta deposits, cm	Distance from center to furthest ejecta, cm	*Calculate*: depth/diam.	*Calculate*: kinetic energy in ergs

Craters on the Moon

The top picture shows the crater Clavius (220 km diameter, 130 miles). The bottom left picture is the full Moon showing bright rays from several young craters, especially the crater Tycho (100 km diameter, 60 miles). The bottom right picture shows the elongated crater Schiller (220 km, 130 miles). H. Newsom, Newsom@unm.edu